MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

ETN4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(All sections/Groups)

24 OCT 2017
2:30 p.m. – 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) State ONE advantage and ONE disadvantage of single mode fiber and multimode fiber. [4 marks]

(b) A step-index optical fiber has a core diameter of 54 μm, a core refractive index of 1.488 and a cladding refractive index of 1.444. The wavelength of light propagating in the fiber is 1330 nm.

(i) Calculate the critical angle at the core-cladding interface. [2 marks]

(ii) Calculate the numerical aperture of the fiber. Your answer should be up to three decimal points. [2 marks]

(iii) Determine the acceptance angle in air. [2 marks]

(iv) Calculate the number of modes supported by the fiber. [4 marks]

(v) Determine the cut-off wavelength for the fiber to operate as single mode fiber. [2 marks]

(c) Describe the term **Fresnel Reflection Loss** and the parameter that contributes to the amount of Fresnel loss. [3 marks]

(d) State TWO (2) common sources of **extrinsic absorption** in silica optical fiber. [2 marks]

(e) **Stimulated Raman Scattering (SRS)** and **Stimulated Brillouin Scattering (SBS)** are nonlinear scattering effects that cause signal attenuation in optical fiber. Compare TWO (2) differences between these scatterings. [4 marks]

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Question 2 (25 marks)

(a) Laser diode is a suitable light source for long distance optical communication.

(i) Briefly explain TWO (2) properties of a laser diode that makes it suitable for long distance high speed communication. [4 marks]

(ii) Describe how **stimulated emission** and **lasing** in semiconductor laser diode is achieved. Draw the structure of a semiconductor injection laser. [6 marks]

(b) State TWO (2) advantages of light emitting diode (LED). [4 marks]

(c) A photodiode collected 2.4×10^{11} electrons when 3.3×10^{11} photons are incident on it. If the wavelength is 1550 nm, calculate:

(i) the quantum efficiency of the photodiode [2 marks]

(ii) energy of the incident radiation (in eV, electron volt) [3 marks]

(iii) the responsivity of the photodiode [2 marks]

(iv) the received optical power required to obtain a photocurrent of 2 μA. [2 marks]

(d) State TWO (2) sources of noise in a p-n junction photodiode. [2 marks]

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Question 3 (25 marks)

(a) Optical amplifiers are one of the important components that enable high speed long distance communications. Two main categories of optical amplifiers are semiconductor laser amplifier (SLA) and fiber amplifier.

(i) Briefly describe TWO (2) advantages of semiconductor laser amplifier (SLA). [4 marks]

(ii) Fabry-Perot amplifier is one type of semiconductor laser amplifier. Explain the working principle of a Fabry-Perot amplifier. Draw its schematic structure. [5 marks]

(iii) State TWO (2) advantages of erbium-doped fiber amplifiers (EDFA) over semiconductor laser amplifiers (SLA). [4 marks]

(b) The ouput power of Erbium doped fiber amplifier (EDFA) is 33 dBm for an input power of 4 dBm at 1310 nm. Calculate:

(i) the amplifier gain in dB. [3 marks]

(ii) the minimum pump power required when it is pumped at 980 nm. [2 marks]

(c) With a suitable diagram, briefly describe direct intensity modulation scheme. [3 marks]

(d) A bit stream of '101001' is modulated at the transmitter of an optical communication system.

(i) Draw the modulated signal if RZ modulation scheme is used. [2 marks]

(ii) Draw the modulated signal if NRZ modulation scheme is used. [2 marks]

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Question 4 (25 marks)

(a) You are involved in a new telecommunication project to install an optical fiber communication system between two cities via submarine cable. The distance between the two cities are approximately 1600 km apart, and the link should be able to support a signal bit rate of 40 Gbps.

(i) Propose a suitable optical source for your design. Justify your answer. [3 marks]

(ii) Propose a suitable fiber type for your design. Justify your answer. [3 marks]

(iii) Choose the suitable operating wavelength for your system (850 nm, 1310 nm or 1550 nm). Justify your choice. [3 marks]

(iv) Propose the amplifier type to be used in your design. Justify your answer. [3 marks]

(b) An optical fiber link with the length of 15 km is used in a campus local area network. The system parameters are listed in Table Q4.

Table Q4

Fiber attenuation	0.25 dB/km
Minimum received power	-25 dBm
Maximum source power	0 dBm
Total number of connectors	4
Insertion loss at each connector	0.2 dB
Total number of splice	2
Splice loss (for each splice point)	0.03 dB
Source coupling loss	0.1 dB
Detector coupling loss	0.08 dB

(i) Calculate the total attenuation in the link. [5 marks]

(ii) Estimate the received power (in Watt) if the light source is transmitting at its maximum power. [4 marks]

(iii) Calculate the power margin. [4 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	2.998×10^{8} m/s
Electron charge	e	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

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